Overview of the Progress of ICCAP 2004-2005
Cross-disciplinary Approach to Impact Assessment of Climate Changes on Agricultural Production System in Arid Region

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1. Introduction – Research topics of ICCAP

The research project ICCAP - Impact of Climate Changes on Agricultural Production System in Arid Areas - is an on-going project of RIHN (Research institute for Humanity and Nature), to analyze the relationship between climate and agricultural system. It is being implemented as an international joint project in cooperation with TÜBİTAK (The Scientific and Technical Research Council of Turkey). The interests and aims of ICCAP can be summarized as follows:

What impacts will the global warming or climate change have on the agricultural production system in arid areas? How can the system adapt to the changes and what measures should be applied to sustain productivity? This research project aims at identifying the direction and dimension of potential impacts and adaptations in the agricultural production system, based on the projection of future regional climate changes in the east coast of the Mediterranean Sea as the case study region. The basic structure and problems of the agricultural production system are to be elucidated through analyzing cropping patterns and land/water management.

In this paper, the project framework is outlined and the progresses in the Japanese fiscal year 2004-2005, after the interim evaluation in March 2004, are overviewed. The detailed activities and work results of the project are reported in the following parts of this report.

2. Objectives and framework of ICCAP

2.1 Scope of the project

As the world population grows and the demand for food increases, agriculture in arid areas is required to improve its productivity, while its development is severely restricted by water availability. In many arid regions of the world, the development of agriculture and irrigation has resulted in land degradation and desertification, and has also caused serious problems in the hydrological regime with irretrievable changes in the regional hydrological cycle. The changes in agricultural land and water management practices pose serious threats to the sustainability of agriculture itself.

Moreover, future global climate change can provide climatological and hydrological conditions in arid region with substantial changes in temperature, rainfall and evapotranspiration, thus present another challenge or constraint to the agricultural production system. What measures are required to sustain productivity in such an environment?

2.2 Consideration of agricultural "wisdom" through projecting impacts

Agricultural production is intricately related to its surrounding natural elements and phenomena, such as soils, crops, and fauna and flora as well as meteorological, hydrological, geographical and geological conditions of the region. Any change in these conditions, which may result from global climate change, inevitably affects the dynamics of the agricultural ecosystem. This aspect has been the focal point of conventional assessment of climate change impacts on agriculture.

However, agriculture is basically a human activity. To cope with climate and other subsequent changes in natural conditions, humans have adapted to the new environment, or taken appropriate measures accordingly. This reaction is a fundamental characteristic of agriculture. Then now, is the conventional 'wisdom' of agriculture adequate enough to overcome the future global climate change?

Transcending the traditional framework of studies,

this project attempts to comprehend 'the agriculture as a system of relationship between human and nature', with a view to identifying current and future challenges, and effective countermeasures against possible climate changes. The scope of the research is schematically depicted in Fig. 1.

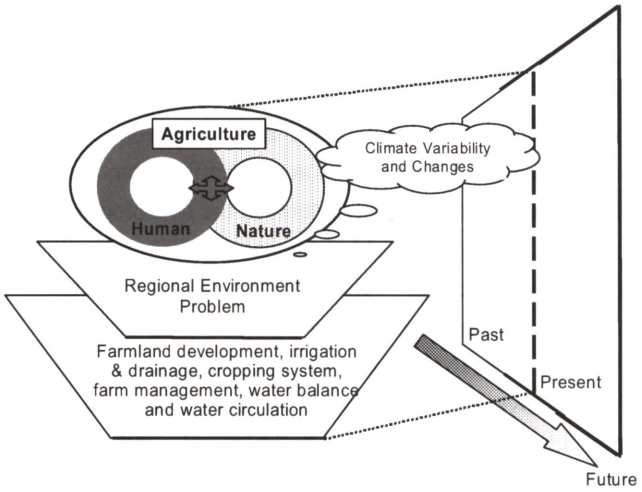

Fig. 1 Scope and framework of the research

Agriculture is based on the interaction of human activities with the natural system including climate changes. This relationship is complex and causes various problems if they malfunction. This project aims at considering this interaction through the investigation of fundamental structure of land and water management as well as through the projections of abrupt climate changes and the assessment of their impacts.

2.2 Main objectives of ICCAP

Main objectives are itemized as four points below, in the research plan.

a) To examine and diagnose the structure of land and water management in agricultural production system in arid areas, especially to evaluate quantitatively the relationship between cropping system and hydrological cycle and water balance in farmland and region.

b) To develop the methodology or model for integrated assessment on impacts of climate change and adaptations for it, mainly on the aspect of the land and water management.

c) To assist the development and improvement of the Regional Climate Model (RCM) for more certain prediction with higher resolution of future changes in regional climate.

d) To assess the vulnerability of agricultural production system and to suggest possible and effective measures for enhancing sustainability of agriculture, through integrated impact and adaptation assessment of climate changes.

2.3 Methodology and case study area

The research of this project is being implemented in the arid and semi-arid areas in the east coast of the Mediterranean Sea, including the Seyhan River basin in Turkey as a main case study area. Firstly we carry out a comprehensive assessment of the basic structure of agricultural production system with special reference to regional climate, land and water use, cropping pattern and irrigation system. Then, it attempts to predict and evaluate the impacts of future climate change and the regional adaptability, and finally through these analyses, the correlations between changes in nature and human activities are to be examined in an integrated manner.

In this process, regional climate change prediction with higher resolution is critical to precise impact assessment. Furthermore, impacts on the regional water resources, irrigation and drainage system, natural vegetation, growth of crops, farm management and cropping patterns as well as the effect on the food production and marketing will be taken into account. Also feedback of agricultural production systems on regional climate will be considered. We aim at providing suggestions for regional policies and monitoring systems as well as accumulating information that will assist to analyze relationship between climate/natural systems and human activities. The research procedures are shown in Fig. 2.

Research works in Turkey are carried out in cooperation with TÜBİTAK, as the international joint project. In the future, we plan to expand the study area into another region like the Nile Delta in Egypt.

3. Brief overview of the progresses of the project

3.1 General

Since the commencement of the project in April 2002, considerable efforts and time have been needed to establish research plan and collaboration system for implementing the project in Turkey. Data acquisition from the governmental authorities also needs considerable official procedures. On the

other hand, however, these efforts and procedures provided the project members with good opportunities for better understandings and collaborations.

In parallel with these research infrastructure preparations, on-site measurement, interviews, collection of statistics and references, model development and laboratory experiments were carried out, in Japan and Turkey as well as in Israel.

In the Japanese fiscal year 2004-2005, based on the research progress and results in the past years, we have continued the works in plan, including method development, model development, observation and measurement and data analysis. The innovated method for assessing the impact of global climate changes on agriculture has been tackled. One of the remarkable progresses is that the Regional Climate Model has been improved and generated future climate scenario with pseud global warming experiments. This output of RCM, called the First Run, is now available for all sub-groups and will be the trigger for progress of each sub-group and integration of them, in coming period.

The progress of the whole project is summarized as follows;

1) Improvement of the research organization and basic data collection in Turkey has been carried out continuously. Collection of topography, geology and soil maps for the Syhan River Basin was fundamentally completed, and the historical records of meteorology and hydrology were also finished. Now, they are under processing in Japan and Turkey.
2) On-site measurements and observations as well as interviews have been executed and their results have been analyzed. In Japan, model development and laboratory experiments are going well satisfactory.
3) To project the future climate condition, the Regional Climate Model is being modified continuously and has generated a future climate scenario in the case study basin with global warming experiments.
4) The scope and method for assessing the climate change impacts on various aspects or phase s of the agriculture in the case study area were discussed. Then, finally and as a hypothesis for

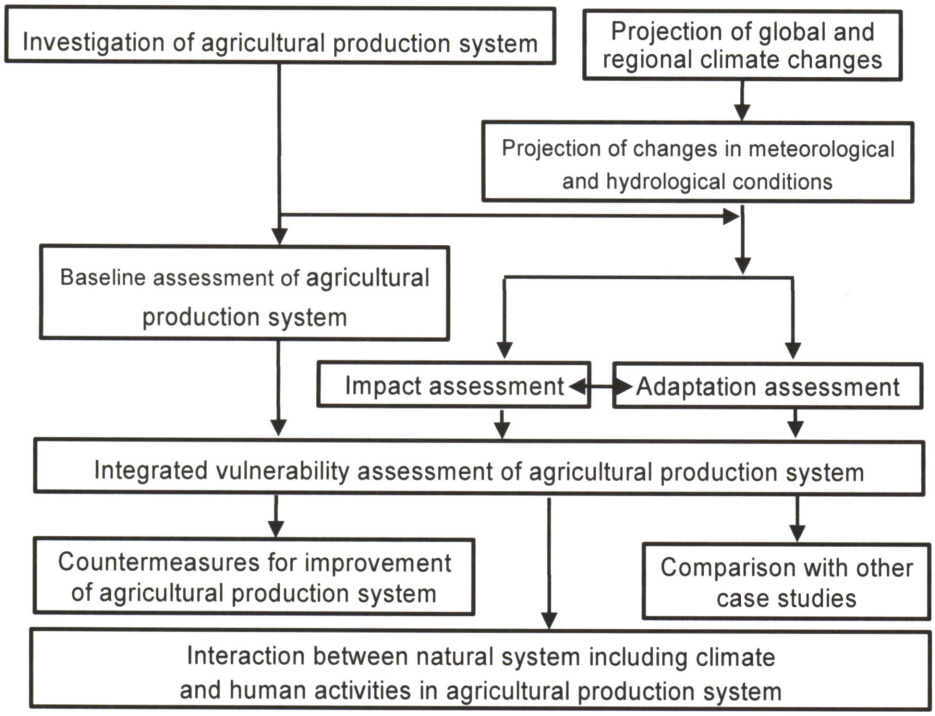

Fig. 2 Research procedure

First the characteristics of regional agricultural production system are analyzed. Then the regional climate change and its adaptability are assessed for integrated evaluation of vulnerability and sustainability of the agricultural production system. This approach comprehensively examines the relation between changes in nature and human activities.

integration, one framework for assessment was illustrated in Fig.3. This framework diagram shows the elements that could be affected by climate change and their relationship. This means it could represent the mechanism of climate change impacts in agricultural production system.

5) In the scope of ICCAP, there are some lacks are to be recognized like changes in pest and diseases, urbanization, population growth, etc. Taking the limitation of resources and time for ICCAP and characteristics of the case study area into account, three sob-topics were added in the scope of the projects; livestock farming, soil salinty in farmland, and women's role in land and water management.

3.2 Progresses of the works of sub-groups

The progresses of each sub-group are summarized as follows.

i) Climate sub-group

a. The daily precipitation data produced by the MRI-CGCM ensemble runs under SRES-A scenario were analyzed. A decrease in precipitation around the Mediterranean region was significant.

b. Analyze of the precipitation data of Turkey (1977-2000) shows the following trends; i) decrease of precipitation in the western region in January, ii) increase of precipitation for whole Turkey in April with a few exceptions, and iii) increase of precipitation in whole Turkey in October except the southern region.

c. By analyzing grid precipitation data and objective reanalysis data (ECMWF), an increasing trend in evapo-transpiration over Turkey was apparent in July.

d. Regional climate model (TERC-RAMS and MM5) was test-run, nested with MRI-GCM output (resolution of 280km.) Monthly rainfall distribution in the 2070s was estimated. The model still cannot simulate year-to-year variation of monthly precipitation. Appropriate nesting grid size and region for better resolution were examined.

e. A dataset of the RCM pseudo warming run version 2 was distributed to all the member of the project. This dataset includes the simulation run of RCM using NCEP/NCAR boundary conditions and the pseud warming run (in 1999 + 80). The dataset includes three hourly precipitation, temperature, wind velocity and downward short wave radiation (insolation) at the observation stations in the entire Turkey (537 stations).

ii) Hydrology and water resource sub-group

a. The distributed hydrological model (Hydro-BEAM), was developed and modified, and then applied to the Seyhan River Basin.

b. Field survey showed that irrigation feeds groundwater in the Seyhan River Delta and the groundwater flows out into the Ceyhan River Delta.

c. The groundwater level of the Lower Seyhan River Delta already comes up to the ground surface in the area, where altitude is lower than about 5 m above the sea level. Even the irrigated farmland extends over the area in the higher land above 5 m from the sea surface, the areas, where groundwater level is 1 m below surface, increase in the irrigation period in the upper to middle basin.

d. Simulation model for salt-water intrusion with expected raised sea-level was developed.

e. Laboratory experiments were carried out to investigate the impact of sea-level rise and validation of this model was conducted.

iii) Crop productivity sub-group:

a. Under glass house condition, and suffered elevated temperature and CO_2 concentration in growth cabinet after one week naturalization, transpiration rate decreased with decrease in soil water contents and there was a curve liner relationship between relative transpiration rate (soil desiccated/irrigated control) and fraction transpirable soil water.

b. A simplified process model to simulate wheat growth and yield under Mediterranean environments (sometimes drought-prone and with a possibility of frost damage) was developed.

c. The model includes 4 processes; phenology, leaf area development, dry matter production and yield formation process considering the frost damage on spikes, and phenology model could be well explained the days to flowering of Adana99 grown under various environmental conditions.

d. Maize productively with temperature raise was simulated by the SWAP model using the predicted climate data of MRI model, as a result, average dry matter weight of first and second crop maize in 2040-2060 decreased by 11.7% and by 14.9% as compared with those in 1981-2010, respectively.

iv) Vegetation sub-group:

a. Impact of global warming and climate change on species composition and productivity of the natural vegetation is being assessed in the Seyhan Basin and the neighboring Ceyhan Basin.

b. In the seven permanent investigation plots in the three typical stands (maquis, *P.brutia* and *Abies/Cedrus*), stand structure and productivity was investigated in those plots. For the vegetation map of the case study basin, geographical vegetation in the eastern Mediterranean region is being analyzed by satellite images.

c. The annual growth of trees was observed to analyze the influence of climate changes on tree growth. Elongation growth of trees in the semi arid area of this region is restricted when annual rainfall amount is less than 1000mm.

d. The vegetation map of the eastern Mediterranean region and the study basins, and in the present, it must depend satellite images. The relationship between present and past vegetation and environment aspects is being analyzed in terms of temperature, precipitation and topography.

e. To clarify present merits of livestock keeping in settled small-scale agro-stock keeping households in the transition phase from transhumance to settled agro-stock keeping in Turkey, the general situation was investigated on the following points; 1) income rate from livestock production in the whole income, 2) breakdown of income from livestock production, 3) expenditure rate for livestock keeping in the whole expenditure, 4) the balance of income and expenditure, and 5) present situation of subsistence, in settled small-scale agro-stock keeping households.

e) Irrigation and drainage sub-group:

a. Data was collected from State Hydraulic Works, which coordinates irrigation projects in the region.

b. Actual water use conditions at two tertiary canals in the project area were monitored. Irrigation intake amounted to nearly three times the actual field application. Irrigation tail water (which was never used) amounted to 25% of the irrigation intakes.

c. Irrigation Management Performance Assessment Model was developed.

d. Broad field survey was carried out to assess salinity problem in the lower part of delta plain. Various conditions of damage were found depending on topography, soil and condition of irrigation.

e. Water Users Associations, which took over irrigation management services from the government, are now suffering from management difficulties due to their small sizes. Improvement of operation efficiency by merging was analyzed. Better efficiency could only be achieved by reduction of the number of staff and by reduction of delayed water fee payment.

f) Socio-economic sub-group:

a. Input-output Model was used to analyze the impact of agricultural crop production in Turkish economy. In the next stage, regional econometric model provided forecasts the impact of climate variability on crop production. In Adana region, temperature had positive impact on yield while in Konya temperature had negative impact on yield and the effect of the precipitation was not significant.

b. The wheat yield in Adana was negatively affected by April rain and positively affected by the December rain in the previous year.

c. Based on the household survey of 184 farmers in 2004, six villages were selected of household survey. The average farm size in rainfed and irrigated agricultural areas was 8.4ha and 15.5ha respectively. The farm income in irrigated areas was US$20,000 per household and four times of that of rainfed areas.

d. Farms in irrigated area employ more agricultural labors, about 2.5 times, compared to rainfed areas. Reliance on female labors in irrigated areas is about one fourth of that in rainfed areas. Also more tenants are found in irrigated areas.

f. Legal institution of land ownership for pasture was studied so as to identify the issues for sustainable management of government, common and private land. Illegal occupation and rehabilitation of government pasture will be analyzed further.

4. Expected Outcomes, Further Plan and Challenges

The ICCAP expects the followings as the final outcomes on the aspect of integrated climate change impacts on agriculture, while it needs further innovated approach in each discipline and in the manner of cross-disciplines.

1) Development of evaluation and simulation models for quantitative analysis of relationship among micrometeorology, soil, water, plant growth and salinity, which would be useful in arid areas.

2) Basic structure of basin hydrological regime and water balance in irrigated region, which can evaluate the role of irrigation on hydrological environment.

3) Development of a tool for integrated vulnerability assessment on agriculture in arid areas.

4) Regional-level climate change scenarios with less uncertainty linked with global climate change.

5) Prediction of changes in hydrological cycle and water resources availability in arid areas, and prediction of crop response to regional climate

change and consequent irrigation water demand changes, corresponding to soil condition, farming system, irrigation management, etc.

6) Socio-economical evaluation of climate change impacts on regional agricultural production system and identification of important elements and critical points for agricultural production and irrigation management in arid areas.

The ICCAP is a research project aiming to make clear the circle of interactions between humans and natural systems, and to build a new research field of the global environment, adopting a more integrated, cross-disciplinary overall perspectives. It could be said that the project is still quite challenging and worth being carried out with better international collaborative approach.

Acknowledgement

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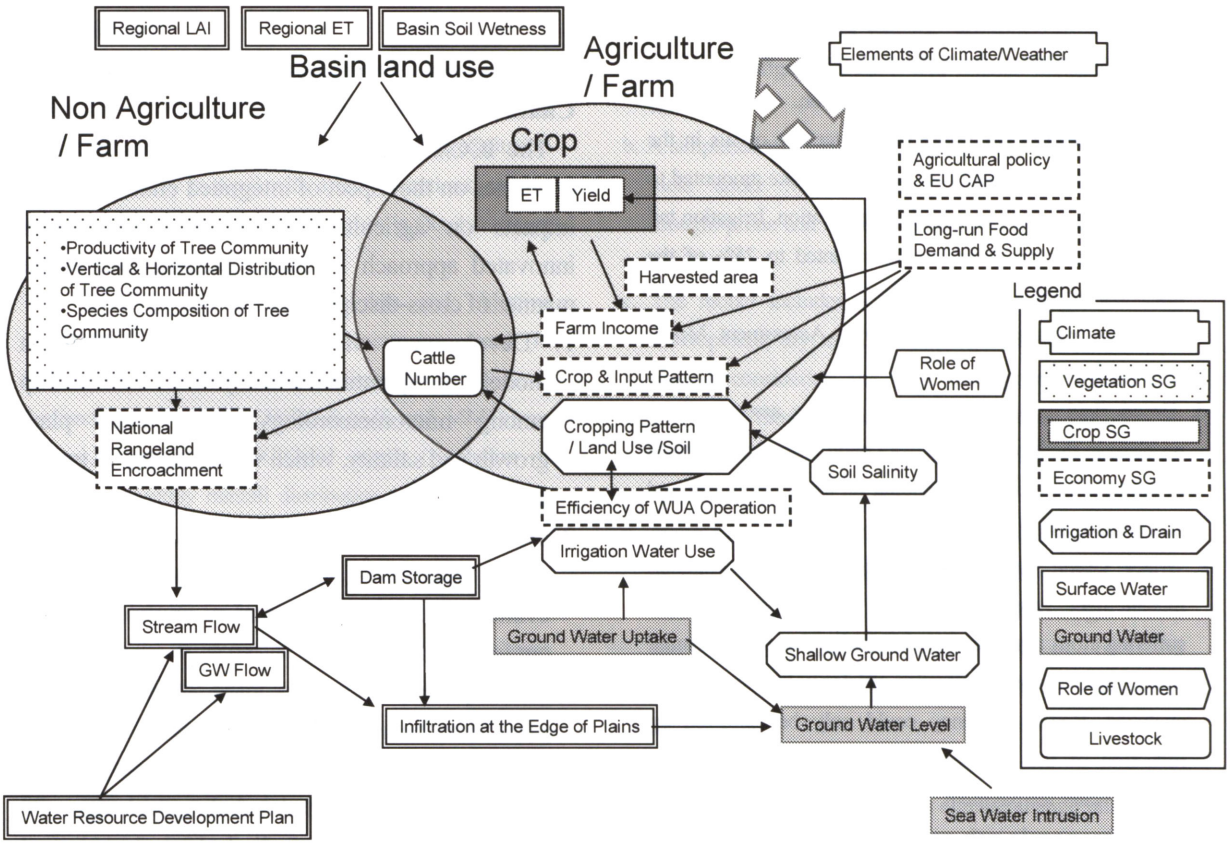

Fig.3 Framework for assessment of impacts of climate changes on agricultural production